

⑫

**EUROPEAN PATENT APPLICATION**

⑲ Application number: 88310334.3

 ⑤① Int. Cl.4: **F 16 D 65/853**  
**F 16 D 55/14**

⑳ Date of filing: 03.11.88

③① Priority: 05.11.87 GB 8725909

 ④③ Date of publication of application:  
 10.05.89 Bulletin 89/19

⑥④ Designated Contracting States: DE GB IT

 ⑦① Applicant: **LUCAS INDUSTRIES public limited company**  
**Great King Street**  
**Birmingham, B19 2XF West Midlands (GB)**

 ⑦② Inventor: **Price, Anthony George**  
**14 Meadow Lane Croesycellio**  
**Cwmbran Gwent NP44 2EY Wales (GB)**
**Campbell, Roy**  
**The Corner House 1 Marlbrook Lane Licky Rock**  
**Bromsgrove Worcestershire (GB)**
**Green, Andrew Peter**  
**22 Park View Pontnewydd**  
**Cwmbran Gwent Wales (GB)**

 ⑦④ Representative: **Spall, Christopher John et al**  
**BARKER, BRETTELL & DUNCAN 138 Hagley Road**  
**Edgbaston Birmingham B16 9PW (GB)**

## ⑤④ Improvements in vehicle disc brakes of the liquid cooled type.

⑤⑦ A temperature sensitive valve (35) is provided in a flow passage (21) of a pressure plate (7). When the brake is cool the valve (35) isolates a pump (P) from a reservoir (20) supplying cooling liquid. The friction produced during braking heats the pressure plate and the valve (35). The valve then opens to communicate the pump (P) with its supply of cooling liquid so that the pump can cool the brake. The valve (35) may be a bi-metallic strip (39) extending radially in a radial portion (36) of the flow passage (21). The radially inner end of the strip (39) is secured to one wall of the passage (21) and the strip is curved when it is cool so that its other end (41) engages a cover plate (38) providing the opposite wall of the passage (21). The end (41) of the strip moves in a direction transverse to the direction of flow of cooling liquid to open the passage (21). Various other pump-isolating valves are shown.

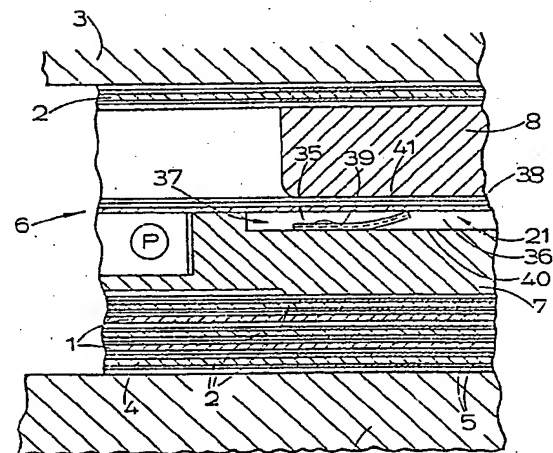


FIG. 4.

## Description

## IMPROVEMENTS IN VEHICLE DISC BRAKES OF THE LIQUID COOLED TYPE

This invention relates to improvements in vehicle disc brakes of the liquid-cooled type, of the kind in which at least one rotatable friction braking member is slidably keyed to a shaft to be braked and is rotatable in a housing containing a cooling liquid for cooling the braking member, and actuating means is provided for urging the braking member into engagement with a relatively stationary braking surface to apply the brake.

Brakes of the kind set forth are commonly used in tractors or the like vehicles, and the cooling liquid usually comprises oil from the gearbox. In order to minimise parasitic drag, particularly when the oil is cool, and conserve consequent power, it is usual for the oil in the gearbox to be maintained substantially at the minimum level only necessary to provide adequate lubrication. This, in turn, creates the problem that such a minimum level represents a volume or depth of oil adjacent to the brake which is normally inadequate to achieve a degree of cooling of the braking member necessary to sustain a minimum wear life for the lining.

It is known to pump cooling liquid to the braking member to maximise the effect of the small volume of cooling liquid.

Also known is PCT patent application No. WO 86/02132, which describes a clutch having a temperature sensitive valve comprising a bi-metallic strip secured to a plate at one end so that its other end covers and seals a circular aperture in the plate when the strip is cool, but bends away from the aperture when the strip is hot allowing flow through the aperture in the direction in which it has bent.

According to a first aspect of the invention, we provide a brake of the kind set forth in which the actuating means comprises at least one pressure plate adapted to be at least axially movable to apply the brake, a flow passage for cooling liquid provided in thermal communication with the pressure plate, and a temperature sensitive valve member provided in the flow passage to regulate the flow of cooling liquid in the passage, the valve member being in a closed condition when the brake is cool in which it obstructs the flow passage and the valve member moving to an open condition in response to heat generated during braking to allow cooling liquid to flow through the passage, the direction of movement in which the valve member moves in response to the heat generated during braking being in a direction transverse to the direction of flow of the cooling liquid in the passage.

Preferably the valve member is provided in the pressure plate, although it could be provided in a stationary member provided in the housing, or in a supply line external of the pressure plate.

When the valve member and flow passage are provided in a pressure plate the plate incorporating the passage and valve member constitutes a second aspect of the invention.

Preferably the flow passage has a radial extent. The valve member may move axially or circumferen-

tially and the cooling liquid flow radially in the passage to cool the brake.

The valve member is preferably a bi-metallic heat sensitive member.

The flow passage may be a radial bore or channel. The valve member may be bi-metallic strip which extends radially in the passage and bends from a position in which it is curved across the passage, obstructing the passage, to a position in which it is straighter and does not obstruct the passage so much.

The flow passage may have an arcuate extent. The valve member may also have an arcuate extent and may be an arcuate portion of a bi-metallic belville washer or spring. The bi-metallic valve member may move axially or circumferentially from its closed to its open condition.

The flow passage may extend through 360°, in which case the valve member could be a bi-metallic belville washer.

The flow passage may be formed as a channel or recess in a main plate element, with a cover plate secured to the main plate element. The bi-metallic valve member may be mounted on an inner surface of the recess. The bi-metallic valve member may be mounted at one of its ends on the bottom of the recess and may extend axially across the recess, so that its other end engages the cover plate when the valve member is cool.

The valve member may carry sealing means to enhance its obstruction of the flow passage, such sealing means could be a resilient strip provided at the mobile end of a bi-metallic strip.

The cooling liquid may be pumped through the flow passage by a pump that is integral with the brake or a pump outside of the brake. Means for disabling the pump so that it only pumps cooling liquid during braking may be provided.

The means for disabling the pump could comprise the temperature sensitive valve member discussed above provided in the flow passage, the flow passage being in the cooling liquid supply line between a reservoir for cooling liquid and the pump. The pump cannot then draw on the liquid in the reservoir until the brake heats up due to braking.

Alternatively or additionally the means for disabling the pump may comprise a first braking surface provided on a rotatable friction braking member rotatable in a housing and slidably keyed to a shaft to be braked, a torque-taking member having a second braking surface provided in the housing which is relatively stationary with respect to the first braking surface during braking, actuator means for bringing the first and second braking surfaces into engagement to apply the brake, means for supplying cooling liquid to the braking surfaces to cool the braking surfaces, and flow control means responsive to torque applied to the second braking surface by the first braking surface during braking to control the supply of cooling liquid to the brake, the arrangement is such that when braking generated torque is

exerted on the torque-taking member the supply of cooling liquid to the braking faces is significantly greater than it is when no braking generated torque is exerted on the torque-taking member. This feature is the subject of a co-pending patent Application filed at the same time as this Application.

Preferably the torque-taking member is provided with a projecting lug and the housing is provided with a complementary lug, the flow control means being provided in one of the lugs and being responsive to relative angular movement between the lugs induced by braking generated torque on the torque-taking member. Preferably the two lugs move relatively together during braking.

Preferably the actuator means comprises an axially movable pressure plate for urging the first and second braking surfaces into engagement.

The pressure plate may comprise the torque-taking member.

The flow control means may comprise an electrical switch provided in the lug of the torque-taking member or the corresponding lug of the housing, the switch controlling the operation of a pump provided to pump cooling liquid to cool the brake.

The pump may be integral with the brake or external of the brake. In one preferred embodiment the flow control is an electrical switch which controls an electrical or mechanical pump so that the pump only operates to pump cooling liquid to the brake when the torque-taking member experiences braking induced torque above a predetermined minimum level.

In another construction the flow control means may comprise a valve in a cooling liquid supply line, the valve allowing the flow of liquid to cool the brake during braking but substantially preventing the flow of liquid when no braking induced torque is applied to the torque-taking member.

Preferably the valve is provided in a cooling liquid supply line between a reservoir of cooling liquid and a pump which the reservoir supplies.

In a brake in which only a small reservoir of cooling liquid is maintained in the housing and the liquid supply line supplies cooling liquid from that reservoir to a pump which pumps the liquid to cool the brake, it is preferred that the valve is provided in the supply line between the reservoir and the pump to isolate the pump from the supply of cooling liquid when no braking induced torque is exerted on the torque-taking member, but allowing fluid to flow to the pump and hence to the braking surfaces when braking induced torque above a predetermined minimum level is applied to the torque-taking member.

Various embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings of which-

Figure 1 shows a general plan view of a disc brake in accordance with the invention;

Figure 2 shows a detail of a slightly modified brake similar to that of Figure 1;

Figure 3 shows another modification of the brake of Figure 1;

Figure 4 and 5 show another detail of the brakes of Figures 1 to 3;

Figure 6 shows schematically another em-

bodiment of the invention.

An oil-immersed brake of the multi-plate type is illustrated in Figure 1 of the drawings and comprises sets of relatively stationary and rotatable friction braking members 1 and 2 which are alternatively interposed within a common housing 3 through which cooling oil is circulated. All the braking members 1, 2 comprise annular discs of which the stationary members are keyed to the housing 3 at their outer peripheral edges for relative sliding movement, and the rotatable members 2 are slidably splined to a shaft to be braked. Each member 1 provides a relatively stationary braking surface against which the corresponding adjacent rotatable member 2 may be brought into engagement. Each stationary member 1 comprises a planar steel plate which may be slotted to prevent coning, and each rotatable member 2 comprises a steel plate 4 provided on opposite sides with linings 5.

An actuator assembly 6 is disposed between a pair of adjacent rotatable members 2, for example replacing a stationary plate. The actuator assembly 6 comprises a pair of pressure plates 7, 8 which are centred on pilots 9 in the housing and are provided in adjacent faces with angularly spaced recesses 10 in complementary pairs of which balls 11 are housed.

A pull-rod 12 is coupled to the inner ends of a pair of toggle links 13, 14 of which the outer ends are coupled to respective radial lugs 15, 16 on the two pressure plates 7 and 8.

The application of the brake is initiated by the pull-rod 12 which withdraws the toggle links 13, 14 to move the pressure plates 7, 8 angularly in the housing 3 in opposite directions. This causes the pressure plates 7 and 8 to separate axially by the balls 11 running up ramps defined by the bases of the recesses 10. This tends to clamp the two sets of friction members 1, 2 together, and the engagement of the pressure plates 7, 8 with the rotatable members 2 causes the two pressure plates 7, 8 to be carried round initially with the members 2 until the movement of one of them is arrested by a stop abutment in the housing 3, suitably defined by the engagement with a torque-abutment lug 17, 18 on that plate with a respective torque, or drag taking lug 19. The lug 19 is in this case also a pilot 9. During braking there is a force between the torque abutment lug of the arrested plate and the torque-taking lug on the housing which counteracts the torque produced on the arrested plate by the slipping of the adjacent and engaged friction member past the stationary surface of the arrested pressure plate. The other plate continues to be carried round with a servo or self-energising action which increases the separation of the pressure plates 7, 8 to enhance the braking.

In the modification of Figure 2, the torque taking lug 17 of the housing is offset from the 6 o'clock position and the pressure plates and friction discs are partially immersed in a reservoir 20 of cooling liquid which is defined by the housing 3. The lug 19 is both a pilot lug and the drag-taking torque abutment lug of the housing, and the lug 17 of the pressure plate 7 is the torque abutment of that plate. The lug 19 is almost completely immersed in the reservoir of

cooling liquid.

A flow passage 21 is provided in the pressure plate 7 extending from the reservoir 20 to a pump P integral with the brake. The pump P pumps cooling liquid to the brake. A suitable pump is that shown in our co-pending Patent Application No. 8717876.

The flow passage 21 comprises a bore in the plate 7 leading from an opening 22 in the circumferential surface 23 of the lug 17 to an inlet for pump P. A through bore 24 extends transversely of the passage 21 from one radial face 25 of the lug 17 to the other radial face 26. The bore 24 is inwardly stepped towards its end 26a which opens out at the radial face 26 adjacent the lug 19. The step is frusto-conically chamfered, with the cone having a large included cone angle, and forms a valve seating for a valve member 27. The valve member 27 is part of a pump-isolating valve 28 which is operable to communicate the pump P with its supply of cooling fluid from the reservoir 20 or to isolate the pump from the reservoir, according to whether the brake is actuated or not.

The valve member 27 is held in the transverse bore 24 and comprises a cylindrical body. One end of the body has a frusto-conical chamfered region 29 from which a spigot 30 extends. The end of the transverse bore 24 which opens to the radial face 26 of the lug 17 is screw-threaded and is closed off by a bolt 31. The bolt 31 is provided with a vent 32. A spring 33 is located between the body of the valve member and the bolt 31 and urges the valve member towards the stepped end of the bore 24. The bolt 31 provides a reaction surface for the spring 33. The diameter of the spigot 30 is smaller than that of the inwardly, stepped end of the bore 24.

When the vehicle is not being braked the valve member is held in the position shown in Figure 2 by the spring 33. In this non-braking condition the body of the valve member obstructs annular fluid path 34 which surrounds the spigot 30, and also obstructs the passage 21. The pump P is isolated from the reservoir 20 so that the pump suction (indicated by arrow S) cannot draw a significant amount of cooling fluid past the valve member 27 when the brake is not braking. The valve member may completely isolate the part of the passage 21 radially inwards of the valve member from the annular passage 34 and the opening 22 of the passage, or it may allow a small amount of leakage.

When the vehicle is braked when it is travelling in its forward direction of travel the friction members are rotating in the direction of arrow F of Figure 2 and the face 26 of torque abutment lug 17 engages the lug 19 of the housing to arrest the angular movement of the plate 7. During the initial moments of braking the spigot 30 contacts the lug 19. The torque on the pressure plate produced by braking overcomes the force of the spring 33 and the valve member is caused to be pushed into the bore 24 as the lug 17 of plate 7 moves into engagement with lug 19 (the spigot of course remains in contact with the lug 19). This opens the flow channels through the annular passage 34 and connects the end 22 of the flow passage 21 to the main part of the flow passage. This allows cooling liquid to enter the inlet of the

pump whereafter it is pumped to cool the braking faces of the brake. The vent 32 allows the fluid in the space between the body of the valve and the bolt 31 to escape as that space is compressed.

When the vehicle is travelling in its reverse direction the lug 17 is not urged towards the lug 19 and the valve member 27 does not move relative to the bore 24. No cooling liquid therefore flows to the pump.

A second valve member may be provided to allow the free flow of cooling liquid to the pump in the reverse direction of travel. The second valve member could be provided in the same lug 17 as the first valve member, or in another lug on the plate 7. The first and second valve members could be combined into a single valve, and may comprise a single member.

When the brake is not applied, and when the vehicle is not travelling forwards, the pump is isolated from the supply of cooling liquid in the reservoir. It is connected to that supply due to the torque induced on the pressure plates by braking when travelling in the forwards direction.

When the direction in which the pump pumps depends upon the direction of rotation of the axle to be braked (for example if the pump is integral with the brake) it is preferred to isolate the pump from the reservoir of cooling liquid. This avoids the pump sucking air and blowing it into the cooling liquid, foaming the cooling liquid.

The brakes of Figures 1 and 2 (and for that matter the brake of Figure 3) has also a temperature sensitive valve member provided in the flow passage 21 radially inwards of the pump isolation valve 28. This is shown in Figures 4 and 5.

The temperature sensitive valve member 35 is provided in a portion 36 the flow passage that extends radially in the pressure plate 7 and which provides communication from the part of flow passage 21 shown in Figures 2 and 3 to the pump P.

The portion 36 of the flow passage 21 is part defined by a channel section groove 37 extending in the pressure plate 7 and part-defined by a cover plate 38 attached to the plate 7 to close off the radially extending side of the groove 37 which would otherwise be open.

The valve 35 comprises a bi-metallic strip 39 located in the portion 36 of the flow passage, obstructing the passage when it is cool and opening the passage when it is warmer. The bi-metallic strip 39 has an elongate length and extends radially in the passage 21. The strip 39 is secured at its radially inner end to the floor wall 40 of the groove 37 by a screw, bolt, rivet, or any other suitable means. The radially outer end 41 of the strip 39 bears on the cover plate 38 when the strip is cool, the strip being curved in an axial direction.

When the strip is cool it obstructs the passage 21 preventing the pump drawing cooling liquid from the reservoir 20. However, during braking the pressure plates heat up due to the friction produced. When this heat affects the bi-metallic strip it bends to open the flow passage, allowing the pump to pump cooling liquid.

It will be noted that the end 41 of the strip moves in

a direction transverse to the direction of flow of the cooling liquid. If the pump applies suction to the passage before the strip has moved away from the cover plate this will merely force the strip further into engagement with the closure plate. The strip may carry a resilient sealing element to improve its sealing of the flow passage.

Although the temperature sensitive valve 35 is described as being used in combination with the torque-sensitive valve 28, either could be used alone.

Figure 3 shows a detail of a brake in many ways similar to that of Figure 2, except that it is a brake in which the pressure plates are not partially immersed in cooling liquid. Similar reference numerals have been given to similar parts.

When the brake of Figure 3 is in a non-braking condition the pump P is isolated from the supply of cooling liquid by a pump-isolating valve. The lugs 17' and 19' are above the level of the reservoir 20' and so a pipe 50 extends from adjacent the end 22' of the passage 21' into the cooling liquid of the reservoir. A hollow connecting piece 51 is received in the end of the passage 21' and connects the pipe 50 to the end 22'.

The valve member 28' comprises a cylindrical spool having a body 52 and a projecting spigot 30' which extends from the body through an inwardly stepped end 53 of a through bore 24' in lug 17'. The spigot 30' carries a sealing flange 54 at a region intermediate in its length. The flange 54 and the body 52 are of substantially the same diameter as the wider portion of the bore 24'. An annular space 55 is defined between the region of the spigot which is between the flange 54 and the body 52 and the transverse bore 24'.

The valve of Figure 3 operates in a similar manner to that of Figure 2. The torque produced at the pressure plate 7' during braking in the forward direction of movement of the vehicle causes the valve member to be moved relative to the bore 24' to register the annular space 55 with the passage 21' so that the pump P is connected to the supply of cooling liquid. The flange 54 and body 52 prevent undue loss of cooling liquid past them into the bore 24', although some leakage may be permissible.

When the pressure plates are not at least partially immersed in cooling liquid, it is preferred to provide a similar pump-isolating valve for the reverse direction of movement of the vehicle.

It will be appreciated that the torque sensitive valve arrangements of Figures 1 to 5 are applicable to servo and non-servo brakes. The temperature sensitive valve 35 is of course applicable to all brakes.

The lug 19 or 19' on the housing need not necessarily be a pilot lug, nor need it be a torque abutment lug of the housing. Similarly, the lug 17 or 17' need not be a pilot lug or the torque abutment lug of the pressure plate. All that is required is that the torque produced at the pressure plate during braking produce a large enough force between the valve member and a surface of the housing to cause the flow passage to be opened.

In a further modification of the torque-sensitive

valves shown in Figures 2 and 3, the torque on the pressure plate produced during braking causes an electrical connection to be made (or broken) and the valve member is controlled electrically, for example by a solenoid.

In a further modification the pump-isolating valve is not provided in a pressure plate but in a relatively stationary braking member, which engages a rotatable friction braking member during braking. The relatively stationary braking member experiences torque produced by braking and so can be considered equivalent in this respect to the pressure plates described.

The pump P could be applying suction to the radially inner part of the flow passage all of the time, or it could only be activated during braking. It could be integral with the brake or remote from the brake.

Figure 6 shows schematically a brake having a pump system that is controlled by the torque force on the pressure plates produced by braking.

A brake 101, pump 102 and reservoir of cooling liquid 103 are connected by liquid supply lines 104. The pump 102 is an electric pump the operation of which is controlled by a switch 105 provided at the brake.

The switch 105 is mounted either in a lug equivalent to lug 19 on the brake housing or a corresponding lug equivalent to lug 17 on the pressure plate and requires a force greater than a predetermined minimum engagement force to be exerted between the lug on the housing and the lug on the plate before it will close to operate the pump 102. The construction of such a switch will be immediately apparent such that the necessary engagement force is provided by the torque abutment engagement force produced on the pressure plate during braking.

The pump system of Figure 6 will only pump cooling liquid to the braking faces of the brake when braking actually occurs. Thus, there may be no necessity for the valve members shown in the constructions of Figures 2-5 to isolate the pump from its supply of cooling liquid when the brake is not being actuated.

The pump system of Figure 6 could be used with similar constructions to those of Figures 1 to 5, but with no valve members, or alternatively it could be used in conjunction with the structures of Figures 1 to 5 including any or all of the valves described.

The pump 102 could be a mechanical pump controlled electrically.

## Claims

1. A disc brake comprising at least one rotatable friction braking member (2) slidably keyed to a shaft to be braked and rotatable in a housing (3) containing a cooling liquid for cooling the braking member (2), and at least one pressure plate (7) adapted to be at least axially movable to urge the braking member (2) into engagement with a relatively stationary

braking surface (1) to apply the brake, characterised in that a flow passage (21) for cooling liquid is provided in thermal communication with the pressure plate (7), and a temperature sensitive valve member (35) is provided in the flow passage (21) to regulate the flow of cooling liquid in the passage (21), the valve member (35) being in a closed condition when the brake is cool in which it obstructs the flow passage (21), and the valve member moving to an open condition in response to heat generated during braking to allow cooling liquid to flow through the passage (21), the direction of movement in which the valve member moves in response to the heat generated during braking being in a direction transverse to the direction of flow of the cooling liquid in the passage (21).

2. A disc brake according to claim 1, characterised in that the flow passage (21) and the valve member (35) are provided in the pressure plate (7).

3. A disc brake according to claim 2, characterised in that the pressure plate (7) comprises a main plate element and a cover plate (38), and the flow passage (21) is formed as a channel or recess (36) in the main plate element, with the cover plate (38) secured to the main plate element and also part-defining the flow passage (21).

4. A disc brake according to any preceding claim, characterised in that the flow passage (21) has a radial extent and the cooling liquid flows radially in the passage (21) to cool the brake.

5. A disc brake according to any preceding claim, characterised in that the valve member (35) is a bi-metallic heat sensitive member (39).

6. A disc brake according to claim 5, characterised in that the valve member (35) is a bi-metallic strip (39) which extends in the passage (21) and bends when it is hot from a position in which it is curved across the passage, obstructing the passage, to a position in which it is straighter and does not obstruct the passage (21) so much.

7. A disc brake according to any preceding claim, characterised in that the flow passage (21) has an arcuate extent and the valve member (35) has a corresponding arcuate extent.

8. A disc brake according to claim 7, characterised in that the valve member (35) comprises at least a portion of a bi-metallic belville washer.

9. A disc brake according to claim 3, characterised in that the valve member (35) comprises a bi-metallic strip (39) mounted at one of its ends on the bottom surface (40) of the recess (36) and extends axially across the recess with its other end (41) in engagement with the cover plate (38) when the strip is cool.

10. A disc brake according to any preceding claim, characterised in that the brake further comprises a pump (P) for pumping cooling liquid to cool the brake from a reservoir (20) via

a cooling liquid supply line (21) leading from the reservoir (20) to the pump (P), and the flow passage and the valve member are provided in the supply line.

11. A pressure plate (7) for use in a disc brake which has at least one rotatable friction braking member (2) slidably keyed to a shaft to be braked and rotatable in a housing (3) having a relatively stationary braking surface (1) and containing a cooling liquid for cooling the braking member, the pressure plate (7) being adapted to be axially movable to urge the braking member (2) into engagement with the relatively stationary braking surface (1) to apply the brake and being characterised in that a flow passage (21) for cooling liquid is provided in the plate (7) in thermal communication with the plate, and a temperature sensitive valve member (35) is provided in the flow passage (21) to regulate the flow of cooling liquid in the passage, the valve member (35) being in a closed condition when it is cool in which it obstructs the flow passage (21), and the valve member (35) moving to an open condition in response to heat generated during braking to allow cooling liquid to flow through the passage (21), the direction of movement in which the valve member (35) moves in response to the heat generated during braking being in a direction transverse to the direction of flow of the cooling liquid in the passage (21).

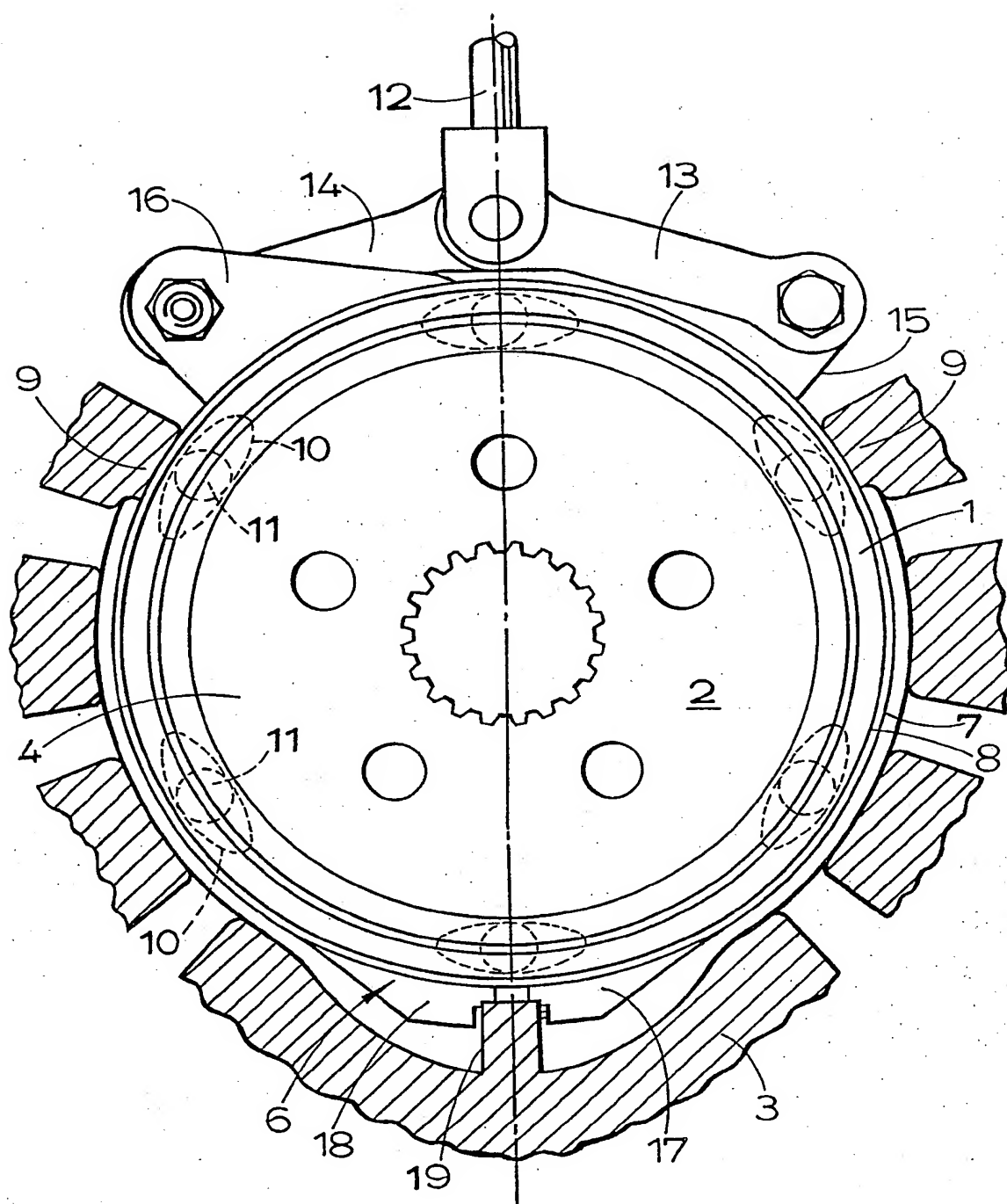
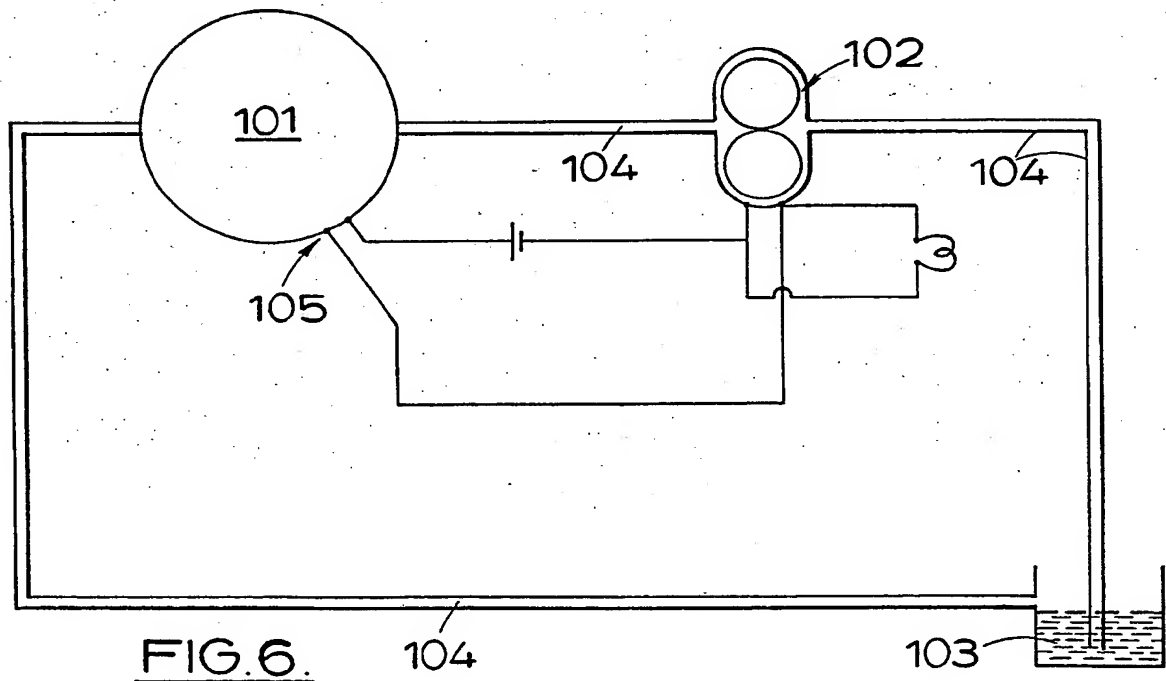
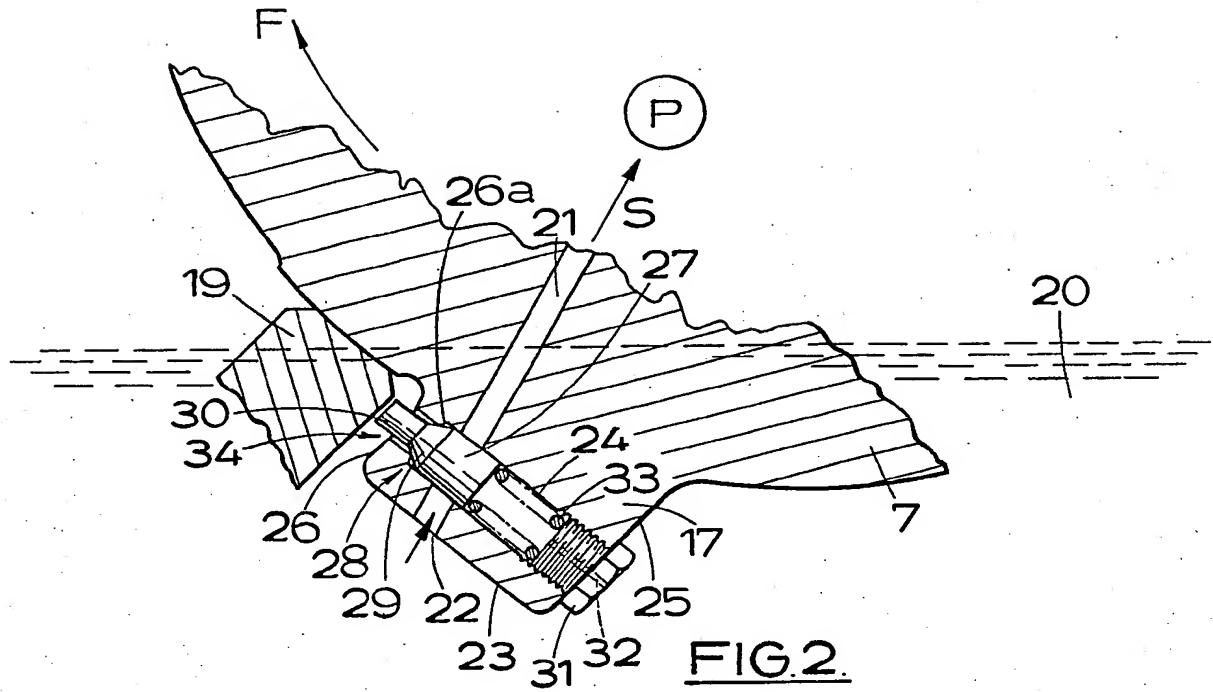


FIG.1.





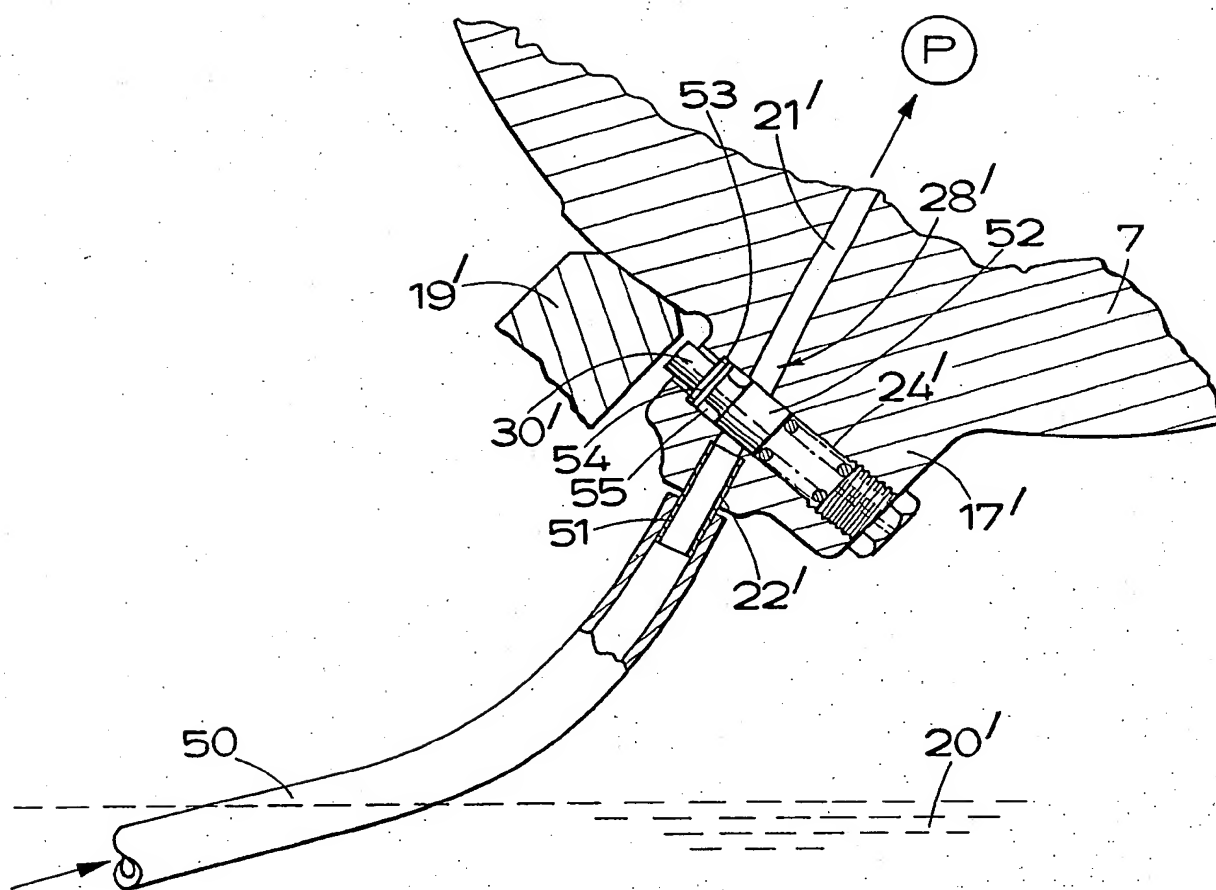
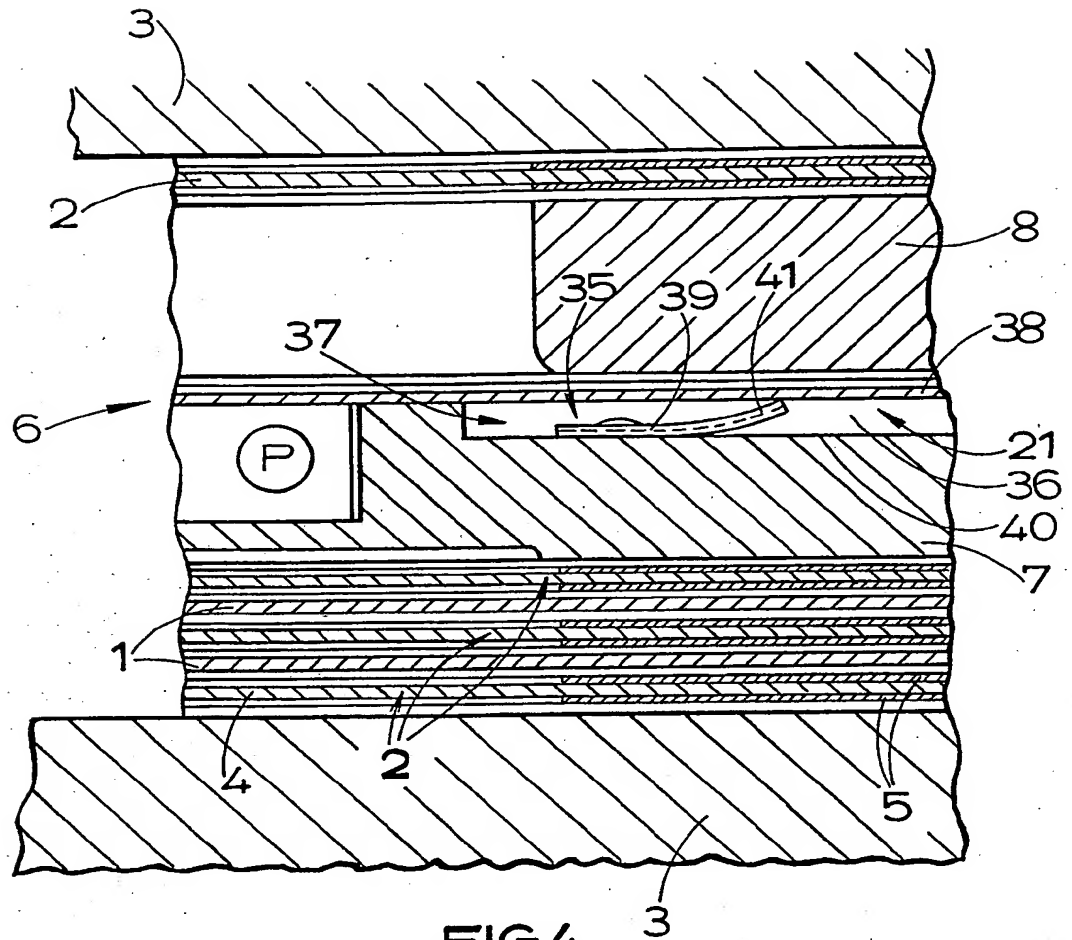
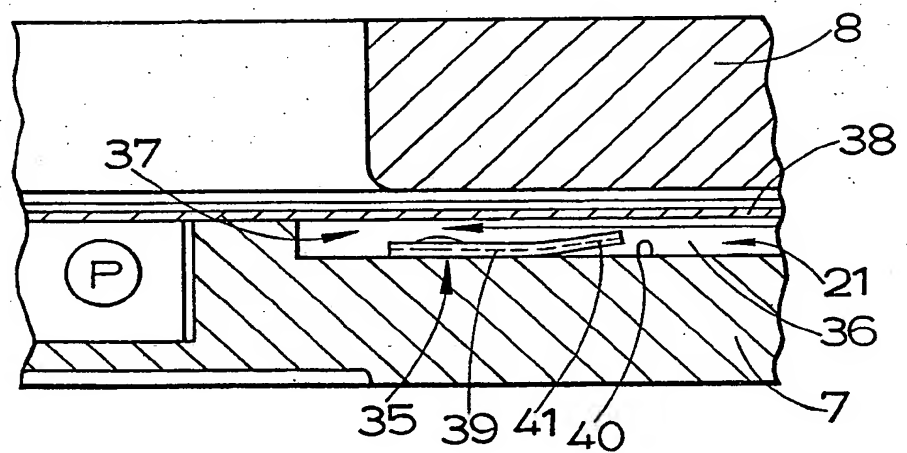


FIG. 3.



**FIG. 4.**



**FIG. 5.**



European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number

EP 88 31 0334

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	GB-A-2 087 998 (MASSEY-FERGUSON SERVICES NV) * Whole document *	1	F 16 D 65/853 F 16 D 55/14
A	GB-A- 788 043 (GENERAL MOTORS CORP.) * Page 3, line 47 - page 4, line 69; figures 6-9 *	1	
A	GB-A- 785 426 (GENERAL MOTORS CORP.) * Page 3, lines 109-117; figure 8 *	1	
A	GB-A-1 440 120 (FERODO LTD) * Page 5, lines 27-61; figure 7 *	1	
A,D	WO-A-8 602 132 (ZAHNRADFABRIK FRIEDRICHSHAFEN AG) * Page 5, line 19 - page 6, line 12; figure 3 *	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			F 16 D 65/00 F 16 D 55/00 F 16 D 25/00 F 16 D 13/00
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 02-02-1989	Examiner BRAEMS C.G.I.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

ETO FORM 1503 01.82 (P0401)

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☒ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**